SIEMENS

TECHNICAL MEMORANUM #3

Getting the Information to the Public

MAG ITS/TE On-Call Services

Contract No. 321-I

Glendale Stadium Area Congestion Map

Proof of Concept Project

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Version 1.0

Submitted To:

Maricopa Association of Governments

Submitted By:

Siemens

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INTRODUCTION

Siemens has been contracted by the Maricopa Association of Governments (MAG) to explore the feasibility of generating a web-accessible congestion map for the arterial street network surrounding the University of Phoenix Stadium and Jobbing.com Arena in Glendale, Arizona. The initial concept is of a congestion map to be developed based on volume and occupancy data from vehicle detectors located at five signalized intersections on the east side of the stadium area. Volume and occupancy values would be extracted from the City of Glendale's i2 Traffic Management System. Algorithms would be developed to correlate volume and occupancy values to congestion levels. Varying levels of congestion would be depicted by colored links on a map. The map would be available to the public via the Internet.

The first task of the project was to perform a field survey of the five signalized intersections around the Glendale stadium to determine what vehicle detectors and raw data are available. Results of the survey are documented in Technical Memorandum #1. The second task was to define algorithms and software interface needs for gathering and processing those data to determine the current level of congestion for each intersection approach or traffic movement. A proposed algorithmic approach and corresponding modifications needed to the i2 central traffic signal system software were reported in Technical Memorandum #2.

This document, Technical Memorandum #3, recommends an approach for displaying the congestion information to the public.

INFORMATION TO BE DISPLAYED

In its initial incarnation, it is anticipated that the system will calculate congestion at five signalized intersections adjacent to the stadium, as reported in Technical Memorandum #1. Where feasible, a separate congestion level will be calculated for each traffic movement on each approach at these intersections, though in general it is unlikely that more than two movements will be monitored on any particular approach. One of the intersections has four major approaches (potentially eight monitored movements per intersection), while the other four intersections have three major approaches (potentially five monitored movements per intersection). The maximum total number of movements for which a congestion level will be reported is therefore expected to be 28.

The system might be expanded in the future to report conditions at more intersections, farther from the stadium. It might also be expanded to show live streaming video from closed circuit television (CCTV) cameras at intersections or other locations of interest, such as the stadium parking lots.

The numerical value associated with the congestion data (e.g., current average detector occupancy in percent, current traffic volume in vehicles per hour) could also be displayed to the user (e.g., in a tooltip). However, these numbers won't be meaningful to a typical traveler, and therefore such a feature is not planned for the initial version of the congestion display system.

DISPLAY FORMAT

Although the congestion information could be displayed in a table or other textual format, it is easier for the public to find the information of interest and understand the traffic movement to which it applies, if it is presented as a graphical overlay on a street map or aerial photograph of the area, as done by the City of Bellevue (http://trafficmap.cityofbellevue.net/). Therefore, the remainder of this report assumes the information will be presented graphically on a map in a web page.

The map could show lines representing streets on a plain background, lines for a street on an aerial photograph background, or just an aerial photo. In any case, street names should be visible to allow users to confirm the location of intersections shown on the map.

Depending on the type, size, and behavior of icons or polylines used to show the congestion level information, it may be necessary to allow users to zoom the map to see more detail. Once zoomed, it will be necessary to also support panning so the user can move the display window to a different part of the map. For example, the Bellevue congestion map supports both zoom and pan controls, with the distinction between through and left turn movement congestion information becoming discernible only after the user zooms in.

MAP SOURCE

The map displayed on the congestion web page could be generated from street centerline data (including street names) from the City's geographic information system, which uses software from ESRI. Alternatively, the map could be a static image drawn in any general-purpose drawing software package. In either case, rectified aerial photography from various sources could be overlaid behind the map, as long as the map and photos are of a consistent scale. Controls could be provided to allow users to turn layers on and off, so that the aerial photography could be removed from the background if desired.

Alternatively, the congestion map could use an on-line mapping service such as Google Maps (http://maps.google.com), Microsoft Live Maps (Virtual Earth - http://maps.live.com), or Yahoo! Maps (http://maps.yahoo.com). These maps provide geo-coded street lines with street names, zoom and pan controls, an optional aerial photography layer, and an application programming interface (API) that allows the map to be embedded in other web pages with custom information overlays, such as the congestion information of interest. These services are free and no license is needed as long as the application is for public use, as in this case.

The on-line mapping services are flexible, mature, stable, reliable, and well supported. Competition between the different service providers, revenue generation from associated advertising, and the large number of users, should ensure that these services remain this way, and remain free for public use, for a long time to come. Given the large number of API users, future API versions are likely to be backward compatible (as have new versions so far), thus minimizing future maintenance. On the other hand, the competition between mapping service providers should generate on-going enhancements to these services, many of which will become automatically available to users of existing embedded applications. The maps and aerial photographs are automatically updated over time to show roadway and land use changes, though it may be a year of more before a change in the field is visible on a particular service's map or photos.

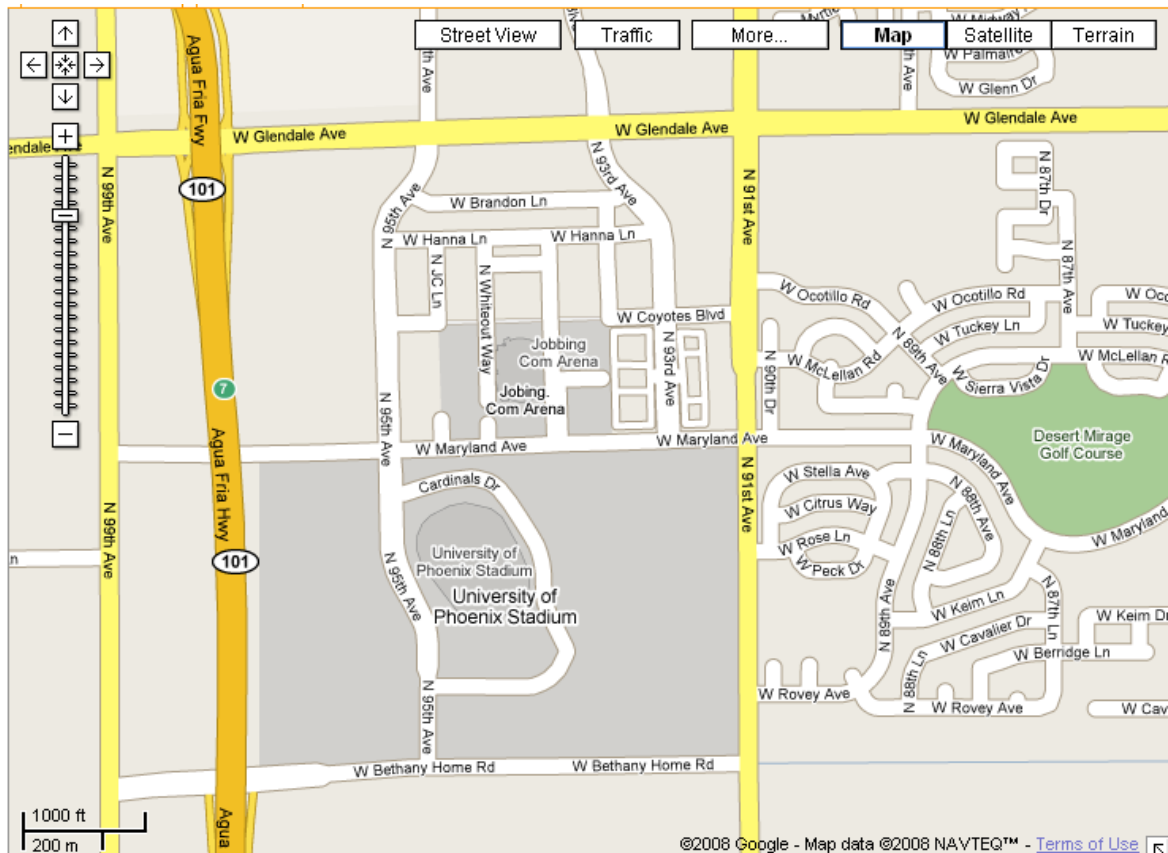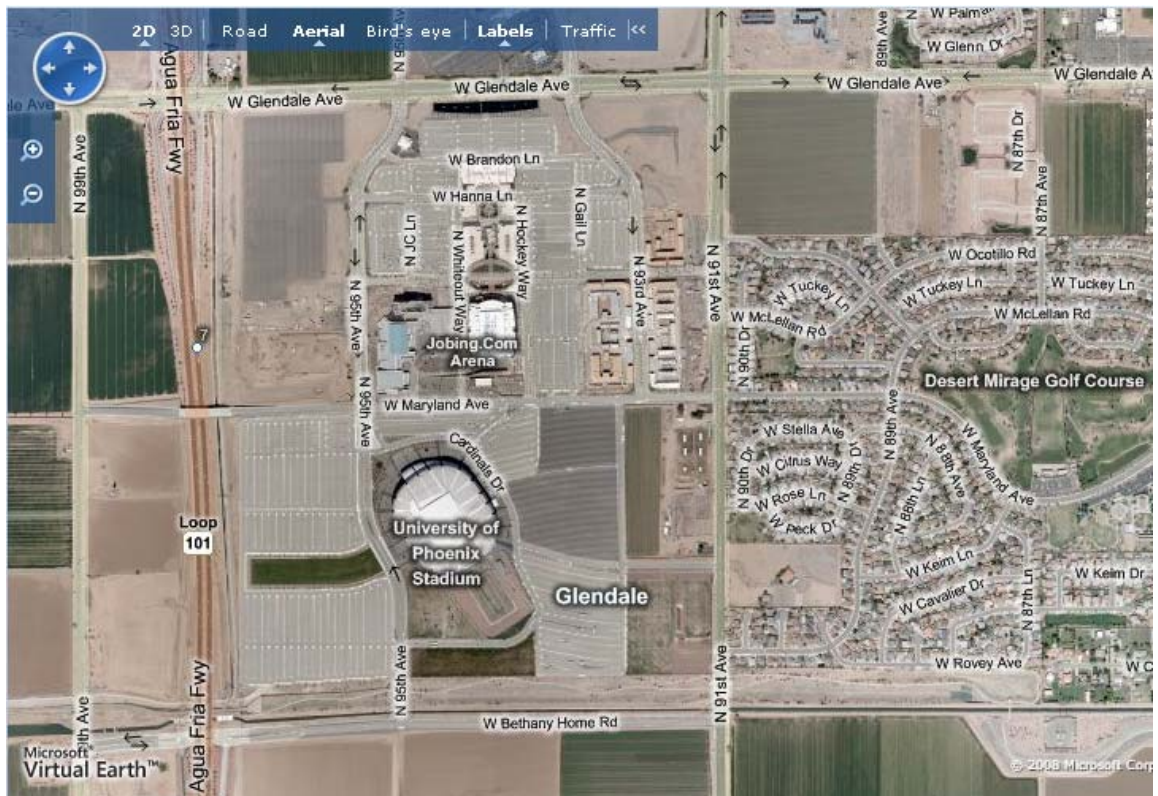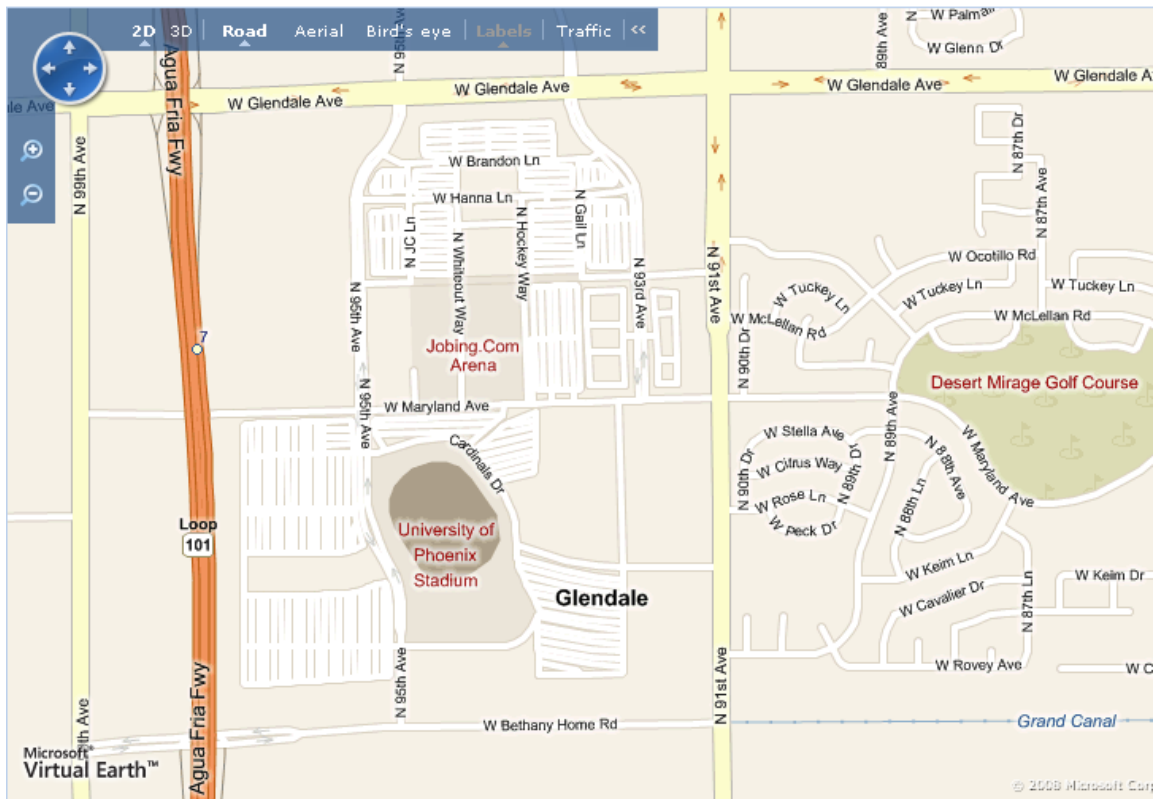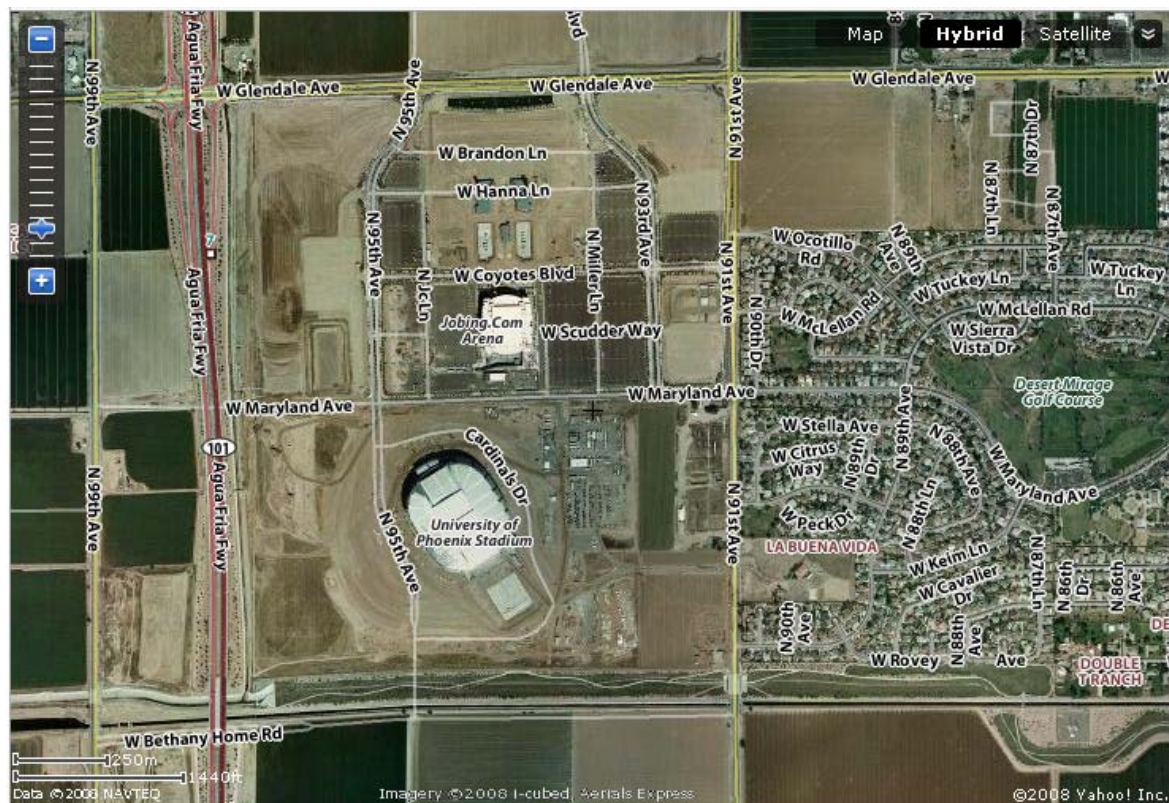# Figure 1 - Apperance of "Google Maps" Map and Aerial Phtography

Figure 2 - Appearance of "Microsoft Virtual Earth" Map and Aerial Photography

Figure 3 - Appearance of "Yahoo! Maps" Map and Aerial Photography

It is also significant that most potential users of the stadium area congestion map will already be familiar with the look and feel of these mapping services, all of which provide similar user options and controls. Furthermore, use of an on-line mapping service makes it very easy to expand the congestion map area to other parts of Glendale as and when needed. Use of an on-line mapping service is therefore the preferred solution for this project.

Figures 1-3 show the appearance of maps and aerial photography in the stadium area currently available from Google Maps, Microsoft Live Maps (Virtual Earth), and Yahoo! Maps. The services are very similar, though there are a few differences that may be significant for this project.

Only Microsoft Live Maps illustrates the stadium and arena parking lots in Map mode. Only Microsoft Live Maps shows the stadium entrance road (6250) connecting directly to 91st Avenue in Map mode. The Yahoo! Maps aerial photography is noticeably out of date compared to the other two offerings. In Map mode, Microsoft Live Maps uses a more subdued color palette, and does not use any of the primary colors being considered for the congestion information overlay (magenta, red, yellow, green). The congestion overlays might therefore stand out better on this map. Microsoft Live Maps does not show the street name for Coyote Boulevard at the zoom level likely to be used for the initial map display.

Although each service has its pros and cons, Microsoft Live Maps (Virtual Earth) seems the preferred mapping service to use for this project. Early in system design the services will be reviewed again to ensure this is still the best choice. Any of these mapping services would be adequate.

The mapping services update their maps and aerial photography periodically, so at any particular point in time, any of the services may be more up to date than the others. Other features such as the color scheme are less likely to change, though they could. It is also possible, though unlikely, that a particular service would go out of business, start imposing advertising unless a fee is paid, or otherwise change the service in a way that would be detrimental to this application.

Therefore, to the extent feasible, the system will be designed to facilitate changing the underlying on-line mapping service in the future. In any case, software modifications will still be needed to switch to a different mapping service.


DYNAMIC INFORMATION ICONS

Figure 4 shows a preliminary concept for illustrating the congestion level on the map. All five icon colors are illustrated in this example (green = light congestion, yellow = moderate congestion, red = heavy congestion, magenta = extreme congestion, gray = no data available). It also shows both through and turn movements being monitored, and all monitored movements being visible simultaneously in a reasonably-sized map window.

This initial conceptual design of the congestion icons is sufficient to prove the feasibility of showing the desired information. In an attempt to further improve the clarity of the information, icons of different shapes (e.g., with and without arrow heads), types (e.g., fixed-size icon versus scalable geocoded polyline), and colors, will be trialed during detailed system design. Consideration will be given to the appearance of the icons as the user

zooms the map or changes to an aerial photography background, including insertion point issues related to fixed-size icons. For the remainder of this document, it is assumed that the congestion graphics will use polylines.

Figure 4 - Conceptual Design of Congestion Icons
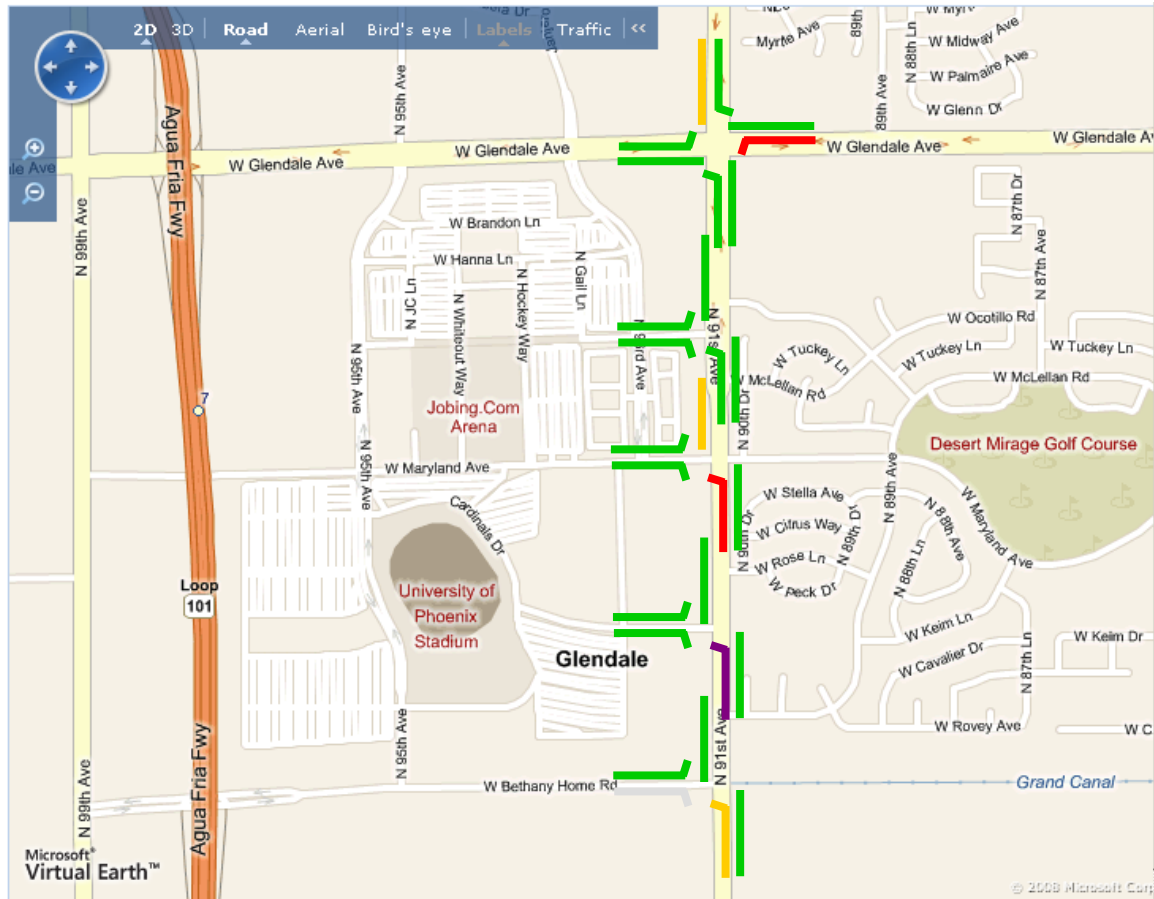
WEB PAGE CONTENT

In addition to the dynamic congestion map described above, the web page will likely include some or all of the following static elements:

- Headline including agency logo.
- Legend explaining the congestion level associated with each icon color.
- Time the dynamic data were last refreshed.
- Acknowledgements.
- Links to other web pages, such as:
    - Help or frequently asked questions (FAQs).
    - Agency home page.
    - Arizona 511 web site.
    - User feedback form.

Some of these elements may appear on top of the map, potentially with transparency to enable the map to still be visible beneath.

SYSTEM OPERATION

About once per minute, the City of Glendale's i2 traffic signal management system will obtain the latest volume and occupancy data from each system detector at each of the five traffic signals of interest. Technical Memorandum #1 describes the vehicle detectors available at the intersections of interest. For each group of detectors monitoring a traffic movement of interest, such data will be passed to a software process that combines the latest data with previous data, and combines data from multiple detectors where applicable, to obtain a smoothed moving average value of occupancy and volume for each traffic movement of interest. The same software will use the combined and smoothed data to calculate the congestion level for the traffic movement. Technical Memorandum #2 discusses alternative algorithms that could be used in this process.

As updated congestion values become available from this process, they will be used to update the parameters that determine the color of the graphical overlay of the congestion map. These graphical elements or icons will be geocoded (a record of their intended location using latitude and longitude) such that they are automatically positioned correctly on the map regardless of the zoom level or pan position of the map.

When a member of the public clicks on a link to the congestion map, or enters its address directly in their web browser, the page will be assembled on their computer screen in real time. The static portion of the page will load first, from a City of Glendale web server (see discussion below), along with script (temporary software) that executes on the user's computer and loads the remainder of the page. The script uses the Virtual earth application programming interface (API) to fetch from the Microsoft Virtual Earth server a suitably configured map of the stadium area at an appropriate initial zoom level, which comes with additional script. This map is placed in the position reserved for the map in the static web page. This map will include at least a subset of the user controls normally available to Virtual Earth users, including zoom, pan, and aerial-view controls.

The static page script will also fetch the geocoded congestion data from the City web server (need not be same web server as serves the static portion of the page). Script will use the Virtual Earth application programming interface (API) and the congestion data to display the congestion icons in the correct positions on the map. Script will also cause the page to automatically refresh the congestion icons periodically, or upon change in the data. If the user zooms or pans the map, script will automatically adjust the position and size of the congestion icons accordingly. This is possible because the Microsoft Virtual Earth server, along with the map image, provides geo data (primarily latitude and longitude) describing the extents and scale of the current map display.

COMPUTER AND COMMUNICATION FACILITIES

At least during system development and initial use (the trial, debugging, and refinement period) the congestion map may need to be served from a web server incorporated with the i2 system and separate from that serving the City of Glendale's main web site. This does not preclude the City's web pages including links to the congestion map, but will avoid the need for City personnel to support the frequent page updates or security issues associated with allowing Siemens personnel to post files directly on the City's servers. If and when the City's information technology personnel are comfortable taking over maintenance of the congestion map web page, it could then be hosted on the City's web server, if the City so

desires, or could remain on the separate server indefinitely and continue to be maintained as part of the traffic signal management system.

To avoid changes to the core i2 traffic management system, the congestion display system will be developed as a separate i2 module. It could operate on a separate computer if needed. At this time it is assumed that a new computer or virtual server will be used for the congestion display system. At least temporarily, it may be necessary to also provide a separate Internet link for this service, along with appropriate security measures.

Glendale already has a communications link between the i2 traffic signal management system server computer at the City's Traffic Management Center and each of the five traffic signals of interest. All other communication links (e.g., between the i2 traffic signal management server and a congestion display system computer and the City's web server if needed) will use either direct Ethernet connection, the traffic signal system's local area network, the City's local/wide area network, or the Internet, as needed. All such links will incorporate appropriate security measures.

It is assumed that at least initially, the level of public use of the new congestion map will be low enough that it can be accommodated within the bandwidth of the City's existing Internet connection or service, although a separate link may be appropriate for security reasons as discussed above. Existing Siemens Internet connections will be sufficient for use during system development and trials.

Decisions concerning computers, web servers, Internet access, security measures, and on-going maintenance will be refined during detailed design in consultation with City information technology personnel. Figure 5 illustrates a likely physical architecture for the congestion display system.

SYSTEM SETUP AND ADMINISTRATION

Existing capabilities of the i2 traffic management system will be used to define and configure appropriate system detectors. This involves three steps as follows:

- Edit and download the signal controller parameters for the five involved traffic signals, to define each detector as a system detector that will then supply volume and occupancy data to i2 when requested. It may also be necessary to adjust or add detection zones in some of the video detection units at some intersections.
- If not already done, configure the i2 communications service to periodically request detector data from the five involved signals. This causes the controller to report volume and occupancy data (or fault code) for all of its system detectors.
- Define those detectors as system detectors in i2. This enables i2 to receive and store volume and occupancy data (and fault codes) for each of the detectors.

No software changes are needed to this part of the i2 system.

Figure 5 - Physical Architecture Concept
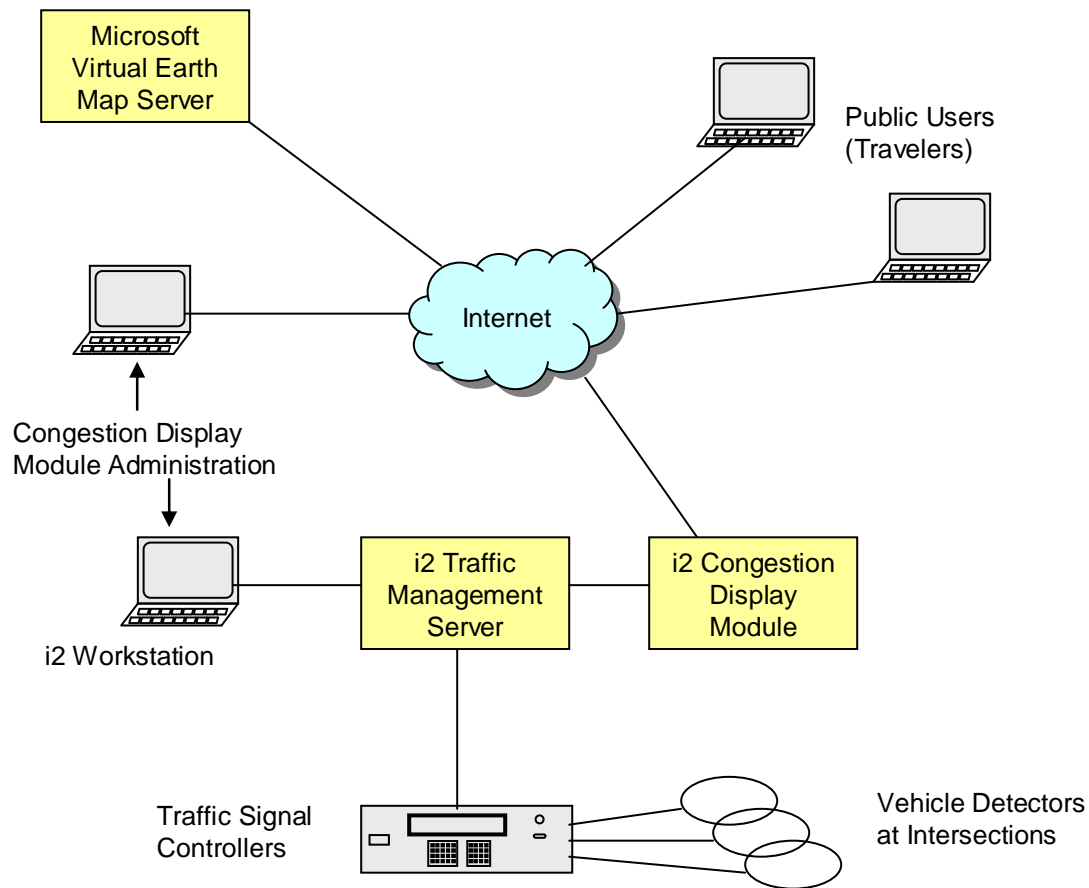
The new congestion display module will monitor the i2 event channel for new instances of detector data from the five signals of interest. When new detector data are thus received by the congestion display module, it will temporarily store those data and process them as described above and Technical Memorandum #2. The outputs of such data processing are the calculated congestion level (color code) for each monitored traffic movement at the five intersections. These congestion levels are supplied to a user's web browser when they retrieve the congestion map web page, as described above.

Configuration of the congestion display module will require a system administrator to input the following parameters:

- The ID of each traffic movement for which a congestion level is being displayed.
- The ID of each detector supplying data for each such traffic movement, by detector type or location.
- Parameters to be used in the formulae that combine and average raw volume and occupancy values into a congestion number.
- Congestion level thresholds used to assign the congestion number to a threshold level.

- For each traffic movement, or detector group, the minimum number of operational detectors needed.
- The latitude and longitude of the vertices, and the line width, for the polyline used to illustrate the congestion level for each traffic movement.
- The color of the polylines for each congestion level.
- Text to display in error messages.

Depending on the final algorithm used, the configuration parameters associated with each detector may be a mixture of dimensionless scaling factors, and measurements of field conditions such as detector length, detector set back, average vehicle length, average free flow vehicle speed, etc.

Initial setup of the congestion display service will also involve creation of the web page into which will be inserted (at page load time) the Virtual Earth map and the congestion graphic overlay. This web page will include the script needed to dynamically create the composite web page, periodically refresh the page, accommodate pan and zoom actions by the user, and handle error conditions including unavailability of the map server.

The congestion display module will support remote administration via the Internet, as well as configuration from any existing i2 workstation. It will likely use a web-based user interface. This interface will use text forms, not a map-based graphical user interface with drop and drag features, for example, though such features could be added in the future if needed.

It is anticipated that during initial system trials, calibration, and validation, configuration parameters will need to be adjusted often. After that, there should be little need for administrative actions, apart from routine check ups.

There are no plans to provide an automatic alert (e.g., text message) facility for notifying administration or maintenance personnel of faults in the system, although this could be added in the future if needed. An uninterruptible power supply with power-failure alarm input to the computer is planned to avoid unexpected system shutdown due to power outages. The system will be capable of unattended startup upon restoration of power. Any data storage will include automatic size limiting measures to avoid disk overflow.

DATA STORAGE

The existing capabilities of the i2 traffic management system will enable the raw detector data to be stored and retrieved if desired. There are no plans at this time to provide a similar user-friendly data storage and historical data retrieval capability for congestion data generated by the congestion display system. Such a capability could be added to the system at any time if needed.

However, for validation and calibration, at least during initial system implementation, it will be necessary to review a history of the congestion calculations and outputted levels. Therefore, a very basic data logging mechanism will be provided, perhaps with the ability to export data to a .CSV file so that Excel can be used for data analysis. This facility will not be available to the public.

In the future, if needed, the system could be enhanced to allow the public to access historical congestion data, including answering the question "how does the current level of congestion compare with the typical level for this day type and time?"

WEB BROWSER SUPPORT

The congestion display system will support and be tested with, as a minimum, the following web browsers:

- Microsoft Internet Explorer versions 6 and above, running on Window XP and Windows Vista.
- Mozilla Firefox versions 2 and above, running on Windows XP, Windows Vista, Linux Ubuntu, and Apple OS X.

The web page will be designed for typical personal computer displays. A separate page optimized for personal digital assistant displays can be added in the future if needed.

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